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(54) **BATTERY MONITORING SYSTEM WITH TIME-BASED DIAGNOSTIC ACTIVATION**

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H01M 10/46 (2006.01)
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USPC 324/426, 427, 431, 433; 320/108, 112, 320/137, 147, 150, 132, 149
See application file for complete search history.

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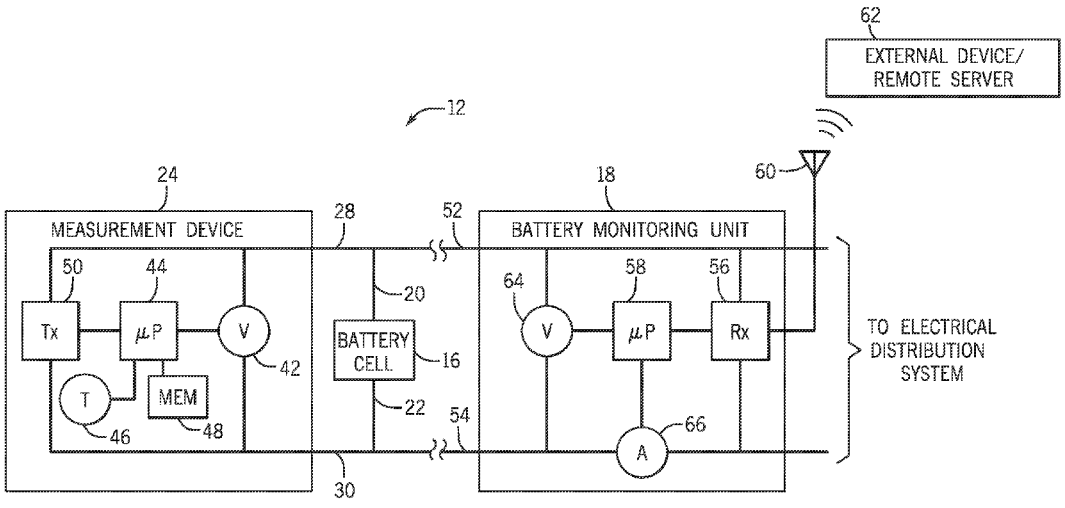
(57) **ABSTRACT**

A battery is provided that includes a battery monitoring system integrated within the battery. The battery monitoring system includes a diagnostic system configured to monitor or store at least one parameter of the battery. Additionally, the battery monitoring system also includes a receiver communicatively coupled to the diagnostic system. Furthermore, the battery monitoring system includes a transmitter communicatively coupled to the diagnostic system and configured to activate upon receipt of a first wireless signal by the receiver and to transmit a second wireless signal indicative of the at least one parameter of the battery.

18 Claims, 5 Drawing Sheets



(51) **Int. Cl.**

G01R 31/36	(2006.01)
B60L 11/18	(2006.01)
H04Q 9/00	(2006.01)

(52) **U.S. Cl.**

CPC *Y02T 90/121* (2013.01); *Y02T 90/128* (2013.01); *Y02T 90/14* (2013.01); *Y02T 90/16* (2013.01); *Y02T 90/163* (2013.01)

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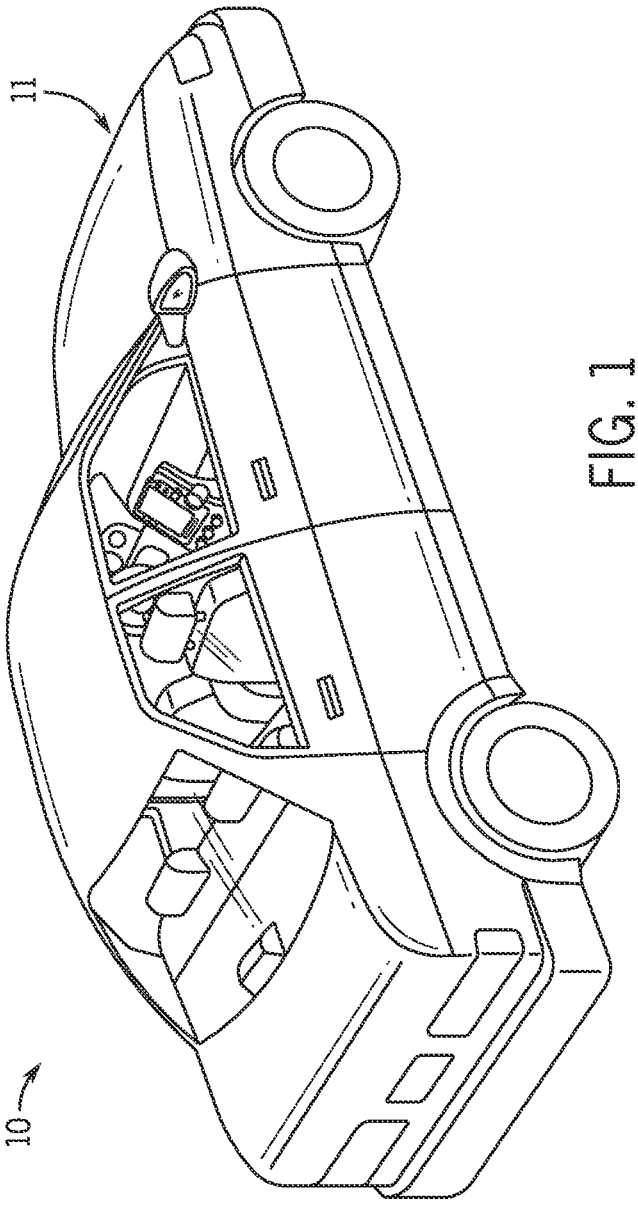

FIG. 1

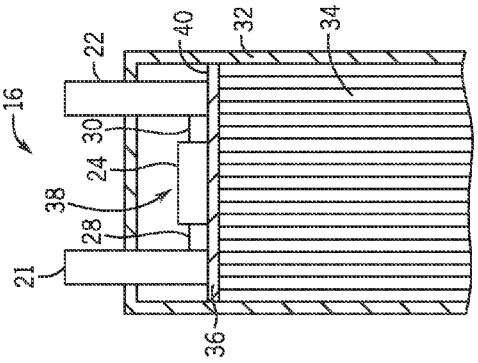
16
22
40
32
34
30
24
38
28
21
36

FIG. 3

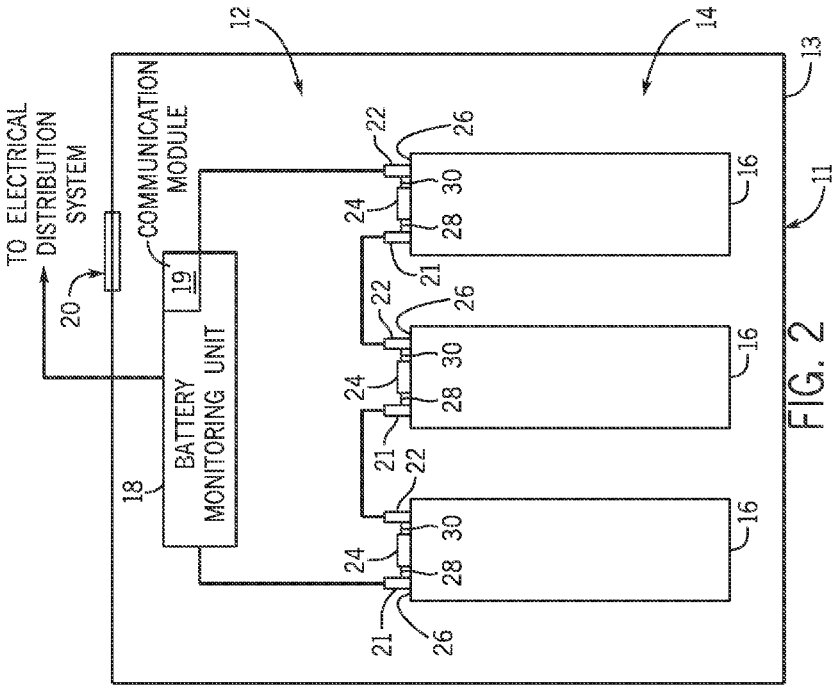
12
14
13
11
TO ELECTRICAL DISTRIBUTION SYSTEM
20
COMMUNICATION MODULE
19
BATTERY MONITORING UNIT
18
22
26
30
28
24
21
16

FIG. 2

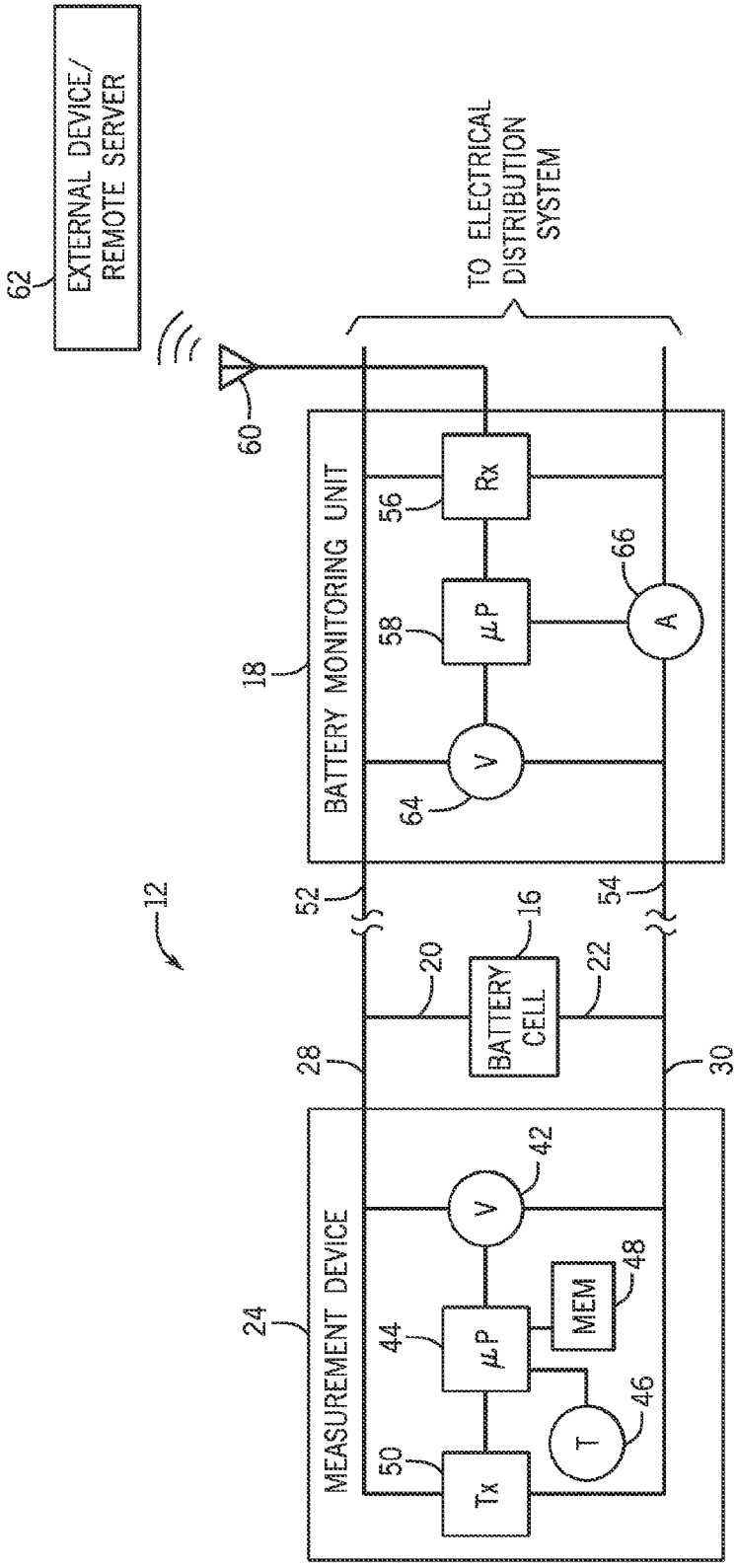
EXTERNAL DEVICE/
REMOTE SERVER
62
TO ELECTRICAL
DISTRIBUTION
SYSTEM
60
BATTERY MONITORING UNIT
18
Rx
56
μP
58
A
66
V
64
12
52
54
16
20
22
BATTERY
CELL
28
30
MEASUREMENT DEVICE
24
V
42
μP
44
MEM
48
T
46
Tx
50

FIG. 4

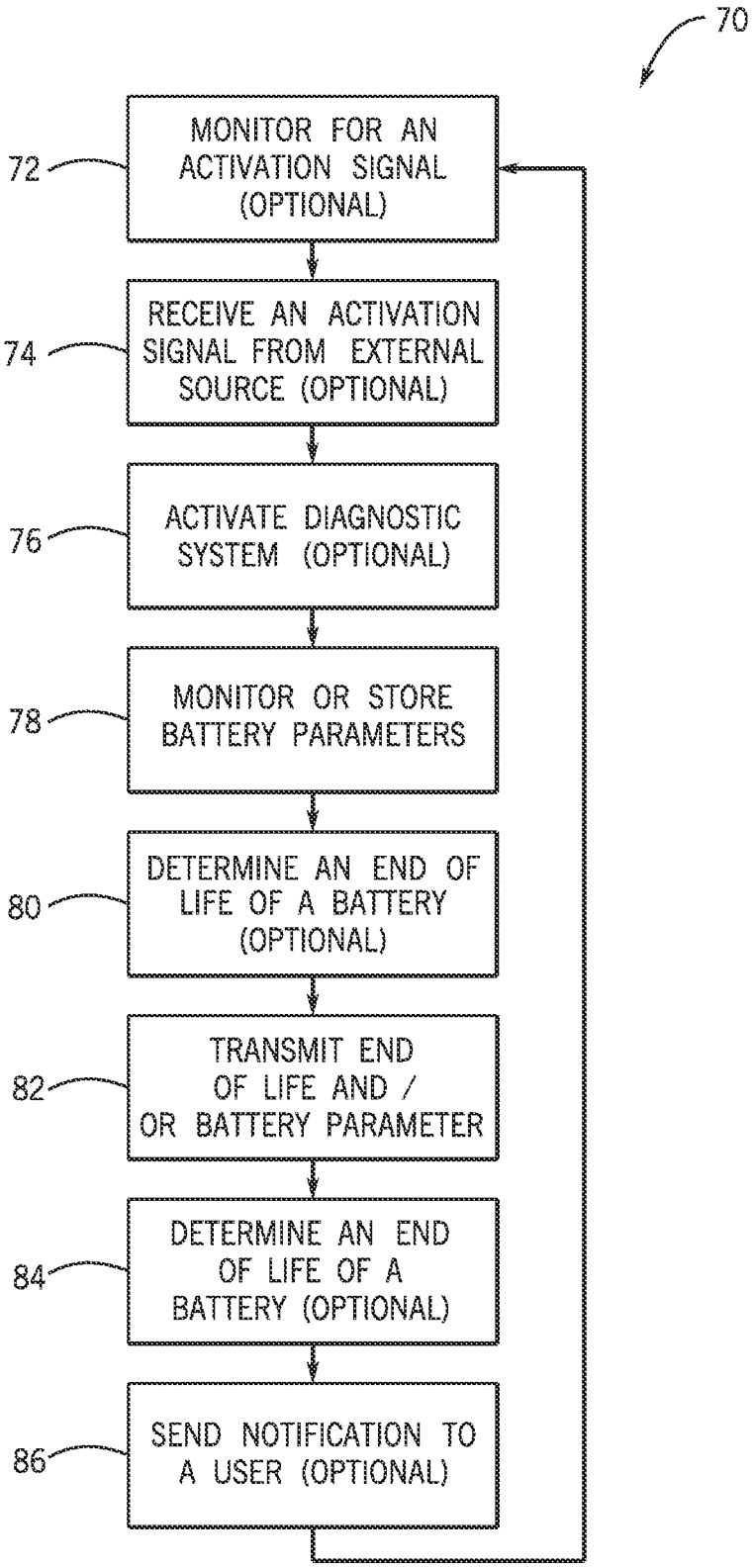
70
72
MONITOR FOR AN ACTIVATION SIGNAL (OPTIONAL)
74
RECEIVE AN ACTIVATION SIGNAL FROM EXTERNAL SOURCE (OPTIONAL)
76
ACTIVATE DIAGNOSTIC SYSTEM (OPTIONAL)
78
MONITOR OR STORE BATTERY PARAMETERS
80
DETERMINE AN END OF LIFE OF A BATTERY (OPTIONAL)
82
TRANSMIT END OF LIFE AND / OR BATTERY PARAMETER
84
DETERMINE AN END OF LIFE OF A BATTERY (OPTIONAL)
86
SEND NOTIFICATION TO A USER (OPTIONAL)

FIG. 5

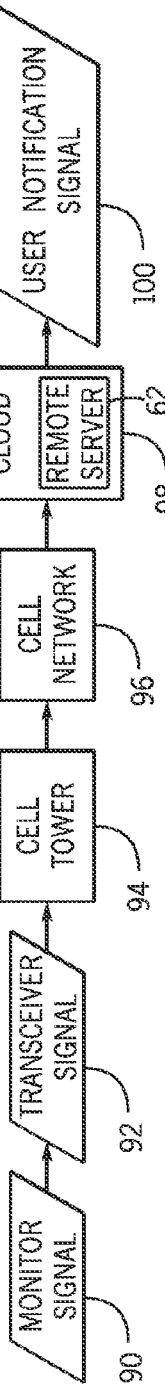

FIG. 6

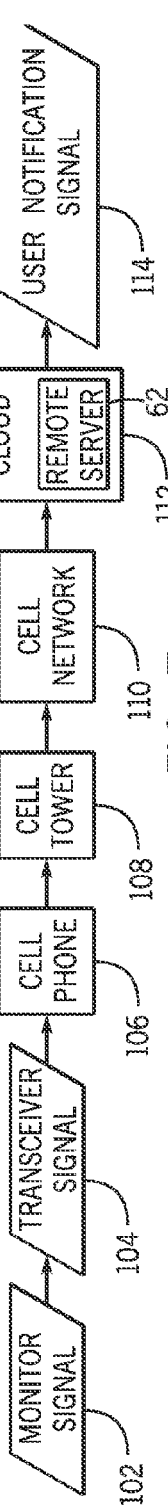

FIG. 7

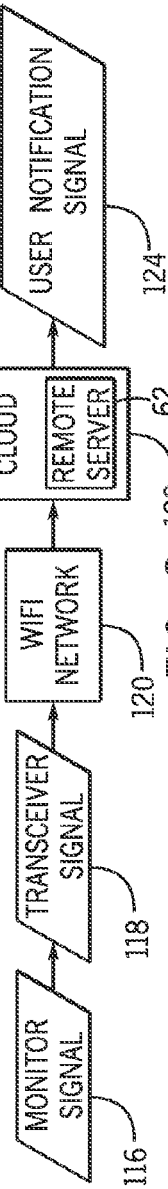

FIG. 8

BATTERY MONITORING SYSTEM WITH TIME-BASED DIAGNOSTIC ACTIVATION

CROSS REFERENCE TO RELATED APPLICATION

This application claims priority from and the benefit of U.S. Provisional Application Ser. No. 61/763,825, entitled "BATTERY MONITORING SYSTEM WITH ON DEMAND DIAGNOSTIC ACTIVATION", filed Feb. 12, 2013, which is hereby incorporated by reference in its entirety.

BACKGROUND

The present disclosure relates generally to a battery monitoring system that provides on demand diagnostic activation.

Certain devices (e.g., vehicles) incorporate batteries to enable device activation and/or operation of various electrical systems within the device. Unfortunately, batteries lose efficiency after various periods and/or conditions of use. Moreover, some batteries contain manufacturing defects that negatively affect the productivity of the battery. Accordingly, it is desirable to monitor a status of the battery via a battery tester either periodically and/or after manufacture. Certain battery testers enable a user to determine whether the battery has a charge or is operable. However, these battery testers usually monitor the battery through physical connections to terminals of the battery. Unfortunately testing using a physical connection to the terminals employs special equipment that may not be available when desired and/or may decrease the efficiency of testing the batteries.

BRIEF DESCRIPTION

In one embodiment, a battery includes a battery monitoring system integrated within the battery. The battery monitoring system includes a diagnostic system configured to monitor at least one parameter of the battery or store the at least one parameter of the battery. Additionally, the battery monitoring system also includes a receiver communicatively coupled to the diagnostic system. Furthermore, the battery monitoring system includes a transmitter communicatively coupled to the diagnostic system and configured to activate upon receipt of a first wireless signal by the receiver and to transmit a second wireless signal indicative of the at least one parameter of the battery.

In another embodiment, a method for monitoring a battery includes wirelessly receiving a first signal via a diagnostic system integrated within the battery, wherein the first signal is indicative of activation of a transmitter of the diagnostic system. The method also includes monitoring at least one parameter of the battery via the diagnostic system. Furthermore, the method includes wirelessly transmitting a second signal indicative of the at least one parameter of the battery upon receipt of the first signal.

In another embodiment, a battery system includes a battery. The battery system also includes a communication device remote from the battery and configured and to receive a wireless signal. The battery system also includes a battery monitoring system integrated within the battery. The battery monitoring system includes a diagnostic system configured to monitor at least one parameter of the battery. Moreover, the diagnostic system is configured to activate upon a duration of time after manufacture. Furthermore, the battery monitoring system includes a transmitter communicatively coupled to the diagnostic system, and configured to transmit a wireless signal indicative of the at least one parameter of the battery.

DRAWINGS

FIG. **1** is a perspective view of a vehicle that may employ a battery and a battery monitoring system;

FIG. **2** is a block diagram of an embodiment of a battery having a battery monitoring system;

FIG. **3** is a schematic view of an embodiment of a battery cell that may be employed within the battery of FIG. **2**, having a self-contained measurement device;

FIG. **4** is a block diagram of an embodiment of a battery monitoring system; illustrating a battery monitoring unit;

FIG. **5** is a flow diagram of an embodiment of a process for monitoring a battery using a battery monitoring system;

FIG. **6** is a flow diagram of an embodiment of a communication path from a battery monitoring system to a user through a cloud network via a direct connection between the battery monitoring system and a cell phone tower;

FIG. **7** is a flow diagram of an alternative embodiment of a communication path from a battery monitoring system to a user through a cloud network via a connection between the battery monitoring system and a cell phone; and

FIG. **8** is a flow diagram of a further embodiment of a communication path from a battery monitoring system to a user through a cloud network via a WiFi network.

DETAILED DESCRIPTION

One or more specific embodiments of the present invention will be described below. In an effort to provide a concise description of these embodiments, all features of an actual implementation may not be described in the specification. It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which may vary from one implementation to another. Moreover, it should be appreciated that such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.

When introducing elements of various embodiments of the present invention, the articles "a," "an," "the," and "said" are intended to mean that there are one or more of the elements. The terms "comprising," "including," and "having" are intended to be inclusive and mean that there may be additional elements other than the listed elements. Any examples of operating parameters and/or environmental conditions are not exclusive of other parameters/conditions of the disclosed embodiments.

As discussed in detail below, a battery for a device, such as a vehicle (e.g., automobile, watercraft, etc.) may include a battery monitoring system that monitors the battery for an estimated end of life based on electrical, chronological, and/or chemical parameters of the battery. In certain embodiments, the monitoring system may send the end of life information to a user via a remote server or device (e.g., through cloud computing), via a cellular network (e.g., to a cell phone), via email, via a television display, or through other notification methods. Additionally, the battery monitoring system may send other information to the user, such as suitable replacement batteries, locations for purchase, of suitable replacement batteries and/or inventories or prices of local and

internet stores carrying suitable replacement batteries. In other embodiments, the battery monitoring system may communicate information to a user via an infrared or other light signal (e.g., indicator lights).

Additionally or alternatively, the battery monitoring system may remain in a standby mode until a signal is sent to the battery monitoring system to activate a diagnostic system within the battery monitoring system. Upon receipt of the activation signal, the diagnostic system initiates monitoring of battery parameters, and determines an estimated end of life of the battery based on the battery parameters. In other words, in some embodiments, the battery may be tested when a user initiates a diagnostic mode. In certain embodiments, the battery may automatically enter a diagnostic mode after a certain period of time after manufacture (e.g., testing in a manufacturing facility). The battery monitoring system then returns the expected end of life information and/or other information associated with the battery parameters to a user.

FIG. **1** is a perspective view of a vehicle **10** that may include a battery **11** and a battery monitoring system. In some embodiments, the battery **11** may be included in other devices, such as trains, boats, industrial plants, or other suitable devices requiring electrical power. In certain embodiments, the battery **11** includes one or more battery cells configured to power electronic components of the vehicle **10**. For example, the vehicle **10** may include a hybrid propulsion system including a gas-powered engine and an electric motor. Monitoring various parameters of the battery **11** and/or each battery cell may provide data for efficiently operating the battery **11**, and/or for determining an estimated end of life for the battery **11**. For example, in certain embodiments, certain parameters of the battery, such as a time of use, a time since manufacture, the temperature of each battery cell, or group of cells, or other suitable parameters, may be monitored. In some embodiments, these parameters may be used to determine an estimated end of life of the battery. In some embodiments, the voltage of each cell may be measured to provide an accurate determination of the state of charge (e.g., charge status) and/or health of the battery to determine an estimated end of life of the battery.

Certain embodiments described below include a battery monitoring system integrated within the battery **11**. In certain embodiments, the battery monitoring system includes a diagnostic system having at least one sensor configured to monitor one or more operational parameters (e.g., voltage, temperature, etc.) of the battery cell and/or store one or more additional parameters of the battery (e.g., size, manufacturing date, manufacturing location, capacity of the battery, shape, of the battery, technology of the battery (e.g., lead acid battery), etc.). Some embodiments include a processor for determining an end of life of the battery based on the monitored parameters, and a transmitter configured to output a signal indicative of the end of life of the battery and/or the operational parameter. In certain embodiments, the battery monitoring system also includes a receiver configured to receive a signal to activate the diagnostic system. In some embodiments, the receiver and transmitter may be elements of a single transceiver. As discussed in detail below, in some embodiments, the battery monitoring system may be integrated within a sealed housing of the battery **11** to substantially reduce or eliminate the possibility of fumes or particulates, present in an engine compartment from interfering with operation of the battery monitoring system. Accordingly, certain embodiments include wireless/contactless methods of communication between the battery monitoring system and an external device.

In certain embodiments, a transmitter of the battery monitoring system is configured to output a signal indicative of the end of life of the battery and/or an operational parameter of the battery via a wireless communication link. In such embodiments, data cables, which may be employed to communicatively couple the battery monitoring system to a remote receiver, are obviated. The reduction in wiring may substantially reduce the weight and manufacturing costs of the battery monitoring system. In addition, the reduced number of connections may enhance the reliability and efficiency of the monitoring system in the potentially corrosive environment of a vehicle engine compartment. Additionally, the wireless link may be established between the transmitter and a cell phone, cell tower, wireless local area network connection (e.g., WiFi), dedicated infrared device (e.g., maintenance device), manufacturer battery testing device, or other such devices.

FIG. **2** is a block diagram of an embodiment of a battery **11** having an integrated battery monitoring system **12** disposed within a battery housing **13**. As will be appreciated, by locating the battery monitoring system **12** within the battery housing **13**, the battery housing **13** protects the battery monitoring system **12** and its electrical components from the harsh environment typically present surrounding a battery. However, in certain embodiments, the battery monitoring system **12** may be located remote from the battery **11** (e.g., within a separate housing). As illustrated, the battery **11** includes an array **14** of battery cells **16** connected in series to a battery monitoring unit **18**. While three battery cells **16** are included within the illustrated array **14**, it should be appreciated that more or fewer cells **16** may be employed in alternative array configurations. For example, in certain embodiments, multiple battery cells **16** may be grouped into modules, with multiple modules forming the array **14**. In such embodiments, a first bus bar may be electrically coupled to a positive terminal **21** of each cell **16** within a module, and a second bus bar may be electrically coupled to a negative terminal **22** of each cell **16** within the module. The bus bars, in turn, may be electrically coupled to the battery monitoring unit **18** and configured to transfer an electrical power signal from the battery cells **16** to the battery monitoring unit **18**. Multiple modules may be connected in series to form the array **14**, and to provide a desired electrical power output to the vehicle electrical system. In alternative embodiments, individual battery cells **16** and/or modules may be connected in parallel, or any other suitable arrangement involving parallel and serial configurations.

Additionally, the battery monitoring unit **18** includes a communication module **19** configured to receive and/or transmit signals from external devices. For example, in some embodiments, the communication module **19** may include a light emitting transceiver that communicates with external devices. In such embodiments, a translucent/transparent window **20** may be included in the battery housing **13**. The window is configured to enable optical light signals (e.g., infrared signals) to pass through the battery housing **13**. For example, in some embodiments, the communications module **19** may receive an optical light signal from a remote device that instructs the battery monitoring unit **18** to transition from a standby mode to a diagnostic mode. The battery monitoring unit **18** may then respond to the remote device using flashing lights or infrared signals that pass through the translucent/transparent window **20**. Alternatively, the battery housing **13** may be configured to enable light signals (e.g., certain patterns or colors) or infrared signals to pass through any surface of the battery housing **13** without the inclusion of a window **20** by constructing the battery housing of a transparent or

translucent material. Moreover, certain embodiments of the battery monitoring system **12** may include a communication module **19** that includes a transmitter capable of communicating through radio frequency signals, such as via a Bluetooth connection, a wireless local area network connection, a cell phone data connection (e.g., code division multiple access), or other suitable connection. In some embodiments, the battery monitoring unit **18** may initiate a diagnostic mode after a certain lapse of time. For example, in some embodiments, the battery monitoring unit **18** may enter into a diagnostic mode after a tracked time in the battery monitoring unit **18** has crossed a threshold, such as 1, 2, 3, 4, 5, or more minutes after manufacture of the battery **11**.

In the illustrated embodiment, a measurement device **24** is mounted to an exterior surface **26** of each battery cell **16**. In certain embodiments, the measurement device **24** is affixed to the exterior surface **26**. As discussed in detail below, each self-contained measurement device **24** includes one or more sensors configured to monitor an operational parameter of the battery cell **24**, and a transmitter configured to output a signal indicative of the operational parameter to the battery monitoring unit **18**.

As illustrated, each self-contained measurement device **24** includes a first lead **28** coupled to the positive terminal **21** of a respective battery cell **16**, and a second lead **30** coupled to the negative terminal **22** of the battery cell **16**. In certain embodiments, the transmitter is communicatively coupled to the first and second leads **28** and **30**, and configured to output the signal indicative of the operational parameter via modulation of a power signal output by the battery cell **16**. In further embodiments, the sensor (e.g., voltmeter) may be coupled to the first and second leads **28** and **30**, and configured to measure a parameter of the power signal (e.g., voltage). Although the illustrated embodiment includes one self-contained measurement device **24** for each cell **16**, some embodiments may include more or fewer self-contained measurement devices **24**. For example, some embodiments may include self-contained battery measurement devices **24** that are configured to monitor or store overall battery parameters for the battery (e.g., battery voltage rather than cell voltage, battery temperature, battery type, battery size, etc.). In some embodiments, the self-contained measurement devices **24** may be stored in suitable locations other than those illustrated. For example, in some embodiments, one or more self-contained measurement devices **24** may be located on the battery housing **13**, and used to monitor the temperature within the battery housing **13**. Additionally, in some embodiments, one or more self-contained measurement devices **24** may be included within the battery monitoring unit **18**, and may measure the voltage of the array **14** of batteries, a cell **16**, or a group of cells **16**.

In embodiments in which the self-contained measurement device **24** is mounted directly to the exterior surface **26** of the battery cell **16**, the measurement device **24** may monitor the temperature of each individual battery cell **16**. For example, in certain embodiments, the self-contained measurement device **24** includes a temperature sensor, such as a thermocouple. By placing the temperature sensor in direct contact with the exterior surface **26** of the cell **16**, the temperature sensor may accurately measure the battery cell temperature. In other embodiments, the components of the self-contained measurement system **24**, including the temperature sensor, may be coupled to the surface of an integrated circuit. In such embodiments, mounting the integrated circuit directly to the exterior surface **26** of the cell **16** enables the surface-mounted temperature sensor to measure the temperature of the cell **16**.

In embodiments in which the self-contained measurement device **24** is mounted to the battery cell **16**, spring connectors, wire harnesses, or flex circuit assemblies which couple PCBs to the terminals **21** and **22** may be obviated. Consequently, the possibility of signal degradation associated with worn connectors may be substantially reduced or eliminated. In addition, mounting the measurement device **24** directly to the battery cell **16** enables the cells **16** to be mounted in a variety of orientations and locations within the vehicle **10**.

FIG. **3** is a cross-sectional view of an embodiment of a battery cell **16** including a self-contained measurement device **24**. In the illustrated embodiment, the battery cell **16** includes an exterior casing **32**, a power storage assembly **34**, and an insulator **36**. As will be appreciated, the power storage assembly **34** includes an anode sheet, a cathode sheet, and a separator disposed between the anode sheet and the cathode sheet. In certain configurations, the sheets are wrapped in a spiral configuration and disposed within an electrolyte. Electrical power may be transferred to and extracted from the power storage assembly **34** via the positive terminal **21** and the negative terminal **22**.

As illustrated, the self-contained measurement device **24** is disposed within a gas-venting region **38** between the insulator **36** and the exterior casing **32**. Specifically, the measurement device **24** is mounted to an interior surface **40** of the battery cell **16** adjacent to the power storage assembly **34**. In certain embodiments, the measurement device **24** is permanently affixed to the interior surface **40**. While the measurement device **24** is mounted within the gas-venting region **38** in the present embodiment, it should be appreciated that the measurement device **24** may be mounted to other interior surfaces within the battery cell **16** in alternative embodiments. Mounting the self-contained measurement device **24** within the battery cell **16** may enable the temperature sensor to provide a more accurate measurement than configurations in which the measurement device **24** is mounted on an exterior surface of the battery cell **16**. In addition, because the measurement device **24** may be positioned proximate to the anode and cathode sheets, the device **24** may be configured to directly measure the state of charge within each battery cell **16**.

As will be appreciated, certain battery monitoring systems compare the voltage of the battery cell **16** to an established voltage profile to determine the state of charge. Unfortunately, because the voltage profile varies based on load, an inaccurate state of charge may be reported to a control system or vehicle operator, resulting in inefficient operation of the battery array **14**. To provide a more accurate determination of the state of charge, the self-contained measurement device **24** may include a sensor coupled to the anode sheet and to cathode sheet, and configured to directly measure the charge on the sheets. As a result, a more accurate state of charge may be determined, thereby facilitating efficient determination of the end of life of the battery **11**.

FIG. **4** is a schematic diagram of an embodiment of the battery monitoring system **12**, including the self-contained measurement device **24** and the battery management unit **18**. As illustrated, the self-contained measurement device **24** includes a voltmeter **42** electrically coupled to the first lead **28** and to the second lead **30**. Because the first lead **28** is electrically connected to the positive battery terminal **21** and the second lead **30** is electrically connected to the negative battery terminal **22**, the voltmeter **42** measures the voltage across the battery cell **16**. In the illustrated embodiment, the voltmeter **42** is communicatively coupled to a microprocessor **44**. It should be noted that, while reference is made in the present discussion to a microprocessor, any suitable processing circuitry may be employed, such as field programmable gate

arrays, and so forth. The microprocessor **44** is configured to receive a signal from the voltmeter **42** indicative of the measured voltage, and to compute the voltage based on the signal. For example, in certain embodiments, the voltmeter **42** may output an analog signal proportional to the measured voltage. In such embodiments, the microprocessor **44** may be configured to convert the analog signal into a digital signal, and to determine the voltage based on the digital signal.

In the illustrated embodiment, the measurement device **24** also includes a temperature sensor **46** communicatively coupled to the microprocessor **44**. As previously discussed, the temperature sensor **46** is in direct contact with an interior surface **40** or an exterior surface **26** of the battery cell **16**. Accordingly, the temperature sensor **46** outputs a signal indicative of the battery cell temperature, and the microprocessor **44** determines the cell temperature based on the signal. For example, in certain embodiments, the temperature sensor **46** may output an analog signal proportional to the measured temperature. In such embodiments, the microprocessor **44** may be configured to convert the analog signal into a digital signal, and to determine the temperature based on the digital signal.

While the illustrated measurement device **24** includes a voltmeter **42** and a temperature sensor **46**, it should be appreciated that alternative embodiments may include additional sensors configured to monitor other operational parameters of the battery cell **16**. For example, in certain embodiments, the measurement device **24** may include a sensor configured to measure the state of charge within the battery cell **16**, and/or an ammeter configured to determine current being provided by the cell. In other embodiments, the measurement device **24** may include a pressure sensor configured to detect an excessive pressure within the gas venting region **38**, for example. In some embodiments, the measurement device **24** may include an ohmmeter, or other sensor configured to monitor an electrical, physical, or chemical parameter of the battery cell **16**.

In certain embodiments, the illustrated measurement device **24** also includes a memory **48** communicatively coupled to the microprocessor **44**. The memory **48** may be configured to store battery cell identification information, operational parameter history information, battery cell type information, and/or usage information. For example, a unique identification number may be associated with each battery cell **16** and stored within the memory **48**. In such a configuration, the battery management unit **18** may identify a particular battery cell **16** based on the unique identification number, thereby facilitating communication between the measurement device **24** and the battery management unit **18**. The memory may also be configured to store historical values of measured operational parameters. For example, the memory **48** may store the maximum voltage measured by the voltmeter **42** and/or the maximum temperature measured by the temperature sensor **46**. Such information may be useful for diagnosing faults within the battery cell **16**. Furthermore, the memory **48** may be configured to store usage information, such as average load, maximum load, duration of operation, or other parameters that may be useful for monitoring the operational status of the battery cell **16**.

In the illustrated embodiment, the measurement device **24** includes a transmitter **50** configured to output the operational parameter (e.g., voltage, temperature, etc.) to the battery monitoring unit **18**. As illustrated, the transmitter **50** is communicatively coupled to the first lead **28** and to the second lead **30**. Consequently, the transmitter **50** is communicatively coupled to a first power transmission conductor **52** extending between the positive terminal **21** of the battery cell **16** and the battery management unit **18**, and to a second power transmission conductor **54** extending between the negative terminal **22** of the battery cell **16** and the battery management unit **18**. The first and second power transmission conductors **52** and **54** are configured to transfer a power signal from the battery cell **16** to the battery monitoring unit **18**. In the present embodiment, the transmitter **50** is configured to output a signal indicative of the operational parameter (e.g., voltage, temperature, etc.) via modulation of the power signal. Specifically, the battery cell **16** is configured to output a direct current (DC) signal to the battery management unit **18**. The transmitter **50** is configured to modulate the DC signal with an alternating current (AC) signal indicative of the value of the operational parameter. Any suitable data-over-power modulation, superposition or transmission scheme may be employed.

For example, the voltmeter **42** may output an analog signal to the microprocessor **44** indicative of the measured voltage across the battery cell **16**. The microprocessor **44** converts the analog signal from the voltmeter **42** into a digital signal, and determines the voltage based on the digital signal. The microprocessor **44** then outputs a digital signal indicative of the measured voltage to the transmitter **50**. The transmitter converts the digital signal into an analog AC signal, and modulates the DC power signal based on the AC voltage signal. A similar process may be utilized to output measured temperature values or other operational parameters.

In certain embodiments, the transmitter **50** may be configured to transmit multiple signals indicative of multiple parameters simultaneously or sequentially. For example, the transmitter **50** and/or microprocessor **44** may be configured to multiplex a voltage signal and a temperature signal, and to transmit the multiplexed signal to the battery management unit **18**. As will be appreciated, additional operational parameters (e.g., pressure, amperage, resistance, etc.) may be included in the multiplexed signal. In alternative embodiments, the voltage signal and the temperature signal may be transmitted sequentially (e.g., voltage signal first and temperature signal second). Additionally, in certain embodiments the transmitter **50** may be configured to wireless transmit information from the processor **44** to the battery monitoring unit **18**. In further embodiments, the processor **44** may be omitted, with raw data being sent from respective sensors (e.g., voltmeter **42**) to a central processor in the battery monitoring unit **18**.

As illustrated, the battery management unit **18** includes a transceiver **56** electrically coupled to the power transmission conductors **52** and **54**. The transceiver **56** is configured to receive the AC signal indicative of the measured parameter by monitoring the modulation of the DC power signal. The transceiver **56** is also configured to convert the AC signal into a digital signal indicative of the value of the measured parameter, and to output the digital signal to a microprocessor **58**. The transceiver **56** is configured to transmit information about the parameters and/or the end of life of the battery **12** to a user or an external device/remote server **62** via an antenna **60** or other suitable connection. As will be discussed in detail below, in certain embodiments, the transceiver **56** may send information via the antenna **60** or a direct connection to an external device/remote server **62** to enable the external device/remote server **62** to further process the information. For example, in some embodiments, the transceiver **56** may send infrared signals or activate blinking lights to show various battery conditions (e.g., indicating that battery needs replacement).

In certain embodiments, the transceiver **56** may be configured to receive wireless signals from the transmitter **50** and/or external sources. In such embodiments, the wireless commu-

nication link between the transmitter **50** and the transceiver **56** may be bidirectional. For example, the transceiver **56** may be configured to scan for an activation signal through the antenna **60** or other suitable connection. In some embodiments, the transceiver **56** receives an activation signal, the transceiver **56** is configured to send a signal to the transmitter **50** to activate the measurement device **24**. In such embodiments, if no activation signal is received, each measurement device **24** remains in a standby mode. In some embodiments, the battery monitoring system **12** may activate a standby mode (e.g., low power mode) upon receiving a standby signal from a remote device (e.g., testing device at a manufacture location) through the transceiver **56**. In such embodiments, the battery monitoring system **12** may deactivate the standby mode upon the occurrence of one or more factors. For example, in certain embodiments, the battery monitoring system **12** may deactivate the standby mode and return to a normal operation mode when the battery monitoring system **12** determines that a voltage changes in the battery, a current draw on the battery surpasses a certain threshold (e.g., a current spike), a length of standby (e.g., time in standby mode has surpassed a standby mode time threshold), another suitable factor, or some combination thereof. Additionally or alternatively, some embodiments of the battery monitoring system **12** may deactivate the standby mode upon receipt of a signal via the transceiver **56** (e.g., the activation signal, a repeat of the signal that caused the standby mode, a signal different from the activation or standby signals).

Furthermore, certain embodiments of the measurement device **24** may activate upon receipt of the activation signal. In some embodiments, the measurement device **24** may activate without an activation signal. For example, in some embodiments, the measurement device **24** may activate after a certain period of time. In some embodiments, this period may be a fixed length (e.g., once per day, etc.). In other embodiments, the period may vary over time. For example, some embodiments of the measurement device **24** may activate at a shorter period initially and activate using a longer period after a certain period of time. In certain embodiments, once the period crosses some length threshold (e.g., 1 week), the measurement device **24** may remain in a standby mode until the measurement device **24** is activated.

The microprocessor **58** may output the operational parameter to a display, compute the battery cell state of charge, estimate an end of life, and/or direct information to the transceiver for wirelessly transmission. In certain embodiments, the battery management unit **18** includes a voltmeter **64** and an ammeter **66** communicatively coupled to the microprocessor **58**, and configured to monitor the total voltage and amperage of the battery array **14**. In some embodiments, the temperature sensor **46** may be included in the battery monitoring unit **18** to measure temperature of the entire battery housing **13**. In such embodiments, individual measurement devices **24** may be located separate from the battery monitoring unit **18** by using the voltmeter **64** and ammeter **66** to determine the voltage and amperage parameters of the entire battery array **12** rather than individual cells **16**. As previously discussed, the battery monitoring system **12** and the transceiver **56** are located within the battery housing thereby protecting the electronic components from the environment of the vehicle engine compartment. Furthermore, in some embodiments, one or more measurement devices **24** may be located in the battery monitoring unit **18** rather than on an exterior surface **26** of a battery cell **16**.

The measurement device components described above may be discrete components mounted to a PCB, or elements of an integrated circuit. Furthermore, as previously discussed, the measurement device **24** may be coupled to the exterior surface **26** of the battery cell **16**, the interior surface **40** of the battery cell **16**, or the battery housing **13**. While a single self-contained measurement device **24** is shown in the illustrated embodiment, it should be appreciated that alternative embodiments may include multiple measurement devices (e.g., one measurement device per battery cell **16** or group of cells **16**) communicatively coupled to the battery monitoring unit **18**. In such embodiments, each measurement device **24** may be configured to transmit a unique identification number to the battery monitoring unit **18** along with the AC signal indicative of the operational parameter. Consequently, the battery monitoring unit **18** may associate each received signal with a particular measurement device **24**. Alternatively, some embodiments may include only one measurement device **24** incorporated within the battery monitoring unit **18**.

FIG. **5** is a flow diagram of an embodiment of a process **70** for monitoring a battery. In some embodiments, a diagnostic portion (e.g., measurement device **24**) remains in a standby mode until an activation signal is received. Accordingly, the transceiver **56** monitors for an activation signal (block **72**). The transceiver **56** then receives an activation signal from an external source (block **74**). For example, the activation signal may be sent using a transmitter remote from the system (e.g. outside the vehicle **10**). In such embodiments, the activation signal may include flashing lights of various colors (e.g., infrared) and/or frequencies that pass through the translucent window **20** and/or the battery housing **13**. In embodiments that include an infrared activation signal, the transceiver **56** is configured to activate the diagnostic system in response to any infrared signal. For example, a generic infrared television remote may be used to send any infrared signal to the transceiver **56** to activate the measurement devices **24**. In other embodiments, activation may only be initiated in response to certain infrared commands. In such embodiments, a dedicated maintenance device may be used to activate the diagnostic system at various maintenance locations, point of purchase locations, or manufacture locations. Alternatively, general purpose devices with infrared capability may be programmed to activate the measurement devices **24**. For example, cell phones having infrared capabilities or compatible infrared peripheries (e.g., an infrared dongle) may be used to activate the measurement devices using programmed sequences. In other embodiments, diagnostic systems may be activated through a wireless connection to a cell phone, cell tower, and/or WiFi network.

In embodiments in which the diagnostic system remains in standby mode absent an activation signal, the transceiver **56** transmits a signal to the measurement devices **24** (e.g., either directly to the measurement devices **24** or through transmitter **46**) to activate the diagnostic systems (block **76**) when the transceiver **56** receives an activation signal from an external source (e.g., the external device/remote server **62**). However, some embodiments may include a diagnostic system that is configured to remain in continuous operation. In such embodiments, the diagnostic systems are activated when the system is turned on, or the battery has a charge, receives a current draw, or other variable factors. In some embodiments, the battery monitoring unit **18** may initiate a diagnostic mode after a certain lapse of time. For example, in some embodiments, the battery monitoring unit **18** may enter into a diagnostic mode after a tracked time in the battery monitoring unit **18** has crossed a threshold, such as 1, 2, 3, 4, 5, or more minutes after manufacture of the battery **11**. The battery monitoring system **12** monitors battery parameters (e.g., voltage, current, and temperature) for the battery **11** using the diagnostic system and/or stores additional parameters (e.g.,

battery size, battery shape, etc.) (block **78**). In some embodiments, the battery monitoring system **12** determines an end of life of the battery **11** using measured battery parameters (block **80**). For example, when voltage produced by the battery declines over a certain period of time, the battery monitoring system **12** may calculate a period of time (e.g., days) left until the battery **11** is expected to need replacement. Alternatively or additionally, the battery monitoring system **12** may track the period of time that the battery has been used to determine whether the battery **11** should be replaced (e.g., by coupling the duration of operation to the expected battery lifetime).

The end of life information (if previously determined) and/or monitored battery parameters are transmitted (block **82**) to a user or to the external device/remote server **62**. In some embodiments, the transmittal may include illuminating an LED on the battery **12**, or other location in the system (e.g., vehicle **10**). However, certain embodiments of the battery monitoring system **12** may transmit the information to a remote server or to an infrared device capable of interpreting the transmittal. The transmittal may also include other relevant information such as location of the system (e.g., vehicle **10**), additional determined battery parameters (e.g., battery manufacturer and/or model), and/or information about the system (e.g., vehicle model for the vehicle **10**, location, engine size, battery size, other additional parameters, etc.). The transmittal may be performed on demand (e.g., in response to an activation signal or another query), or may be transmitted under certain conditions. For example, the end of life/battery parameter information may be transmitted when an expected remaining battery lifetime falls below a certain threshold (e.g., 3 months), and/or various battery parameters may be transmitted when the parameters cross certain thresholds (e.g., voltage drops below minimum voltage threshold).

In some embodiments that the battery monitoring system **10** does not calculate and/or transmit the end of life. The end of life may be determined using a remote device, such as a cloud-based network or remote server (block **84**). In various embodiments, a notification may be sent to the user, notifying the user of the end of life information and/or battery parameters (block **86**). In certain embodiments, the notification may occur automatically in response to the transmittal in block **82**. However, in other embodiments, the notifications may be sent when the transmittal includes certain conditions, such as when an estimated end of life is less than a threshold value (e.g., 1 month), or when operating parameters exceed a certain threshold valve (e.g., battery voltage less than minimum voltage). In some embodiments, the notification may include additional information. For example, the notification may include information about service locations in relation to a determined location of the battery (e.g., from a global positioning system in the vehicle or on a portable electronic device). Additionally, the notifications may include coupons or advertisements for batteries suitable for use in the system (e.g., vehicle **10**) for which battery replacement is desired. The notifications may also include battery drain information that may assist the user in determining whether other system issues exist that may have caused a premature end of life of the battery **11**.

FIGS. **6-8** illustrate various embodiments of sending end of life and/or battery parameters to a user through a cloud network having a remote server. FIG. **6** is a block diagram of an embodiment of a method for sending information from the battery monitoring system **12** to a cloud based computing system via cellular phone communication protocols. As illustrated, a monitor signal **90** is generated by the battery monitoring system **12**, and may include information such as the end of life of the battery **11**, battery parameters, location of the vehicle, vehicle information, and/or battery type. The monitor signal is then sent to the transceiver **56**, which then transmits the information as a transceiver signal **92**. Although FIGS. **6-8** refer to a vehicle using a battery, some embodiments may include batteries used in any suitable transportation device or system having a battery (e.g., battery as auxiliary power). Accordingly, discussion referring to a vehicle may alternatively be used to refer to another suitable system (e.g., production line).

In the illustrated embodiment, the transceiver **56** may use various cellular phone data communication standards such as code division multiple access (CDMA), LTE, High Speed Packet Access (HPSA), WiMax, or other suitable cellular phone data communication standards including all-IP network communications. In such embodiments, the transceiver **56** may transmit the information using a cellular phone data communication standard via the antenna **60**. The broadcast cell information is then received by a cell tower **94** and directed into a cell network **96**. The cell network **96** interfaces with the Internet and sends the information to a cloud network **98**. The cloud network **98** enables a user to access the information through cloud-based applications in a web browser or mobile application, for example. Accordingly, the information is stored on a remote server **62** that is remote from the user. In some embodiments, only battery parameter information is sent to the cloud network **98**, and the cloud network **98** determines an end of life from the battery parameter information. Although the data is stored remote from the user, the user may access the information through a database on the remote server using the Internet, for example. In some embodiments, the information may be kept private using secure data connections requiring login information or other identifying information before the information can be accessed. In certain embodiments, this information may be freely accessible by the user. Alternatively, the remote server may generate information to be sent to the user under certain conditions. For example, in some embodiments, when the lifetime of the battery **11** is determined to be less than a threshold value (e.g., less than 1, 2, 3, 4, 5, or 6 months until the end of the battery), a notification may be sent to the user. An electronic notification may be sent in any suitable format. For example, the remote server may automatically generate an email to the user, a message may be sent using short messaging service (SMS) or multimedia messaging service (MMS), a personalized mailing may be printed for sending through the postal service, or an automated voice message may be sent to the user.

FIG. **7** is a block diagram of an embodiment of a method for sending information from a battery monitoring system to a cloud based computing system via a cell phone connection. As illustrated, a monitor signal **102** is created by the battery monitoring system **12**, and may include information such as the end of life of the battery **11**, battery parameters, location of the vehicle/cell phone, vehicle information (e.g., vehicle model, location, engine size, etc.), and/or battery type. The monitor signal is then sent to the transceiver **56**, which then transmits the information as a transceiver signal **104**. The transceiver sends the information to a cell phone **106** using wireless radio connections. For example, some embodiments may broadcast the information using a Bluetooth connection between the transceiver and the cell phone. Other embodiments may broadcast the information to a cell phone using infrared wireless, ultra wideband (UWB) connections, near field communication (NFC), direct connections to the cell phone, or through cell phone peripherals (e.g., dongles and/or adapters). The transmitted information is received by the cell

phone (e.g., using an application on the cell phone). The cell phone/application may then notify the user of relevant information, such as an estimated end of life of the battery, the nearest service locations, advertisements related to batteries, and the type of battery to be replaced. Additionally, the cell phone transmits the information to a cell tower **108**, which conveys the information to a cell network **110**. This transmittal of information may occur with or without the user's notice. For example, the application may run in the background of an operating system on the cell phone, thereby enabling the transmittal of information without user interaction. Thus, the information is sent to the remote server **62** in the cloud network **112**, where it may be stored and processed for sending notifications to the user **114**. In some embodiments, only battery parameter information is sent to the cell network **110**, and the cloud network **112** determines an end of life from the battery parameter information. The cloud network **112** may then send a relevant notification to the user using SMS, MMS, email, phone, or mail, as previously discussed.

FIG. **8** is a block diagram view showing the creation of a notification using the battery monitoring system **12** through a wireless area network connection to notify a user through the remote server **62**. As illustrated, a monitor signal **116** is created by the battery monitoring system **12** and may include information such as the end of life of the battery **11**, battery parameters, location of the vehicle, vehicle information, and/or battery type. The monitor signal is then sent to the transceiver **56** which then transmits the information as a transceiver signal **118**. In the illustrated embodiment, the transceiver **56** is connected to a wireless local area network (WiFi) **120**. For example, the transceiver **56** may connect to a user's WiFi network when the vehicle **10** comes into range of the WiFi router, such as when the vehicle **10** is parked in a garage. Additionally or alternatively, the transceiver **56** may automatically detect and connect to publicly accessible WiFi hotspots. In some embodiments, the battery monitoring system may store authentication information to enable the transceiver to connect to dedicated WiFi networks at certain service and/or manufacture locations. Through the WiFi network **120** the information is transmitted to the remote server **62** in a cloud network **122**. The information is stored in a database in the cloud network **122** on the remote server **62** for the user to access or to be sent to the user in a notification. Thus, the information is sent to the remote server **62** in the cloud network **122**, where it is be stored and processed for sending notifications **124** to the user. In some embodiments, only battery parameter information is sent to the cloud network **122**, and the cloud network **122** determines an end of life from the battery parameter information. The cloud network **122** then sends a relevant notification to the user using SMS, MMS, email, phone, or mail, as previously discussed. Additionally, in some embodiments, the notification through a home WiFi may be displayed on a television or other display device in the home that is also connected to the WiFi network either directly (e.g., connects to WiFi router) or indirectly (e.g., coaxial connection to cable box that connects to a router).

In summary, various embodiments of the disclosure include a cloud network **98**, **112**, and **122** that sends a user notification signal **100**, **114**, and **124**. In these embodiments, advertising data regarding vehicle batteries may be stored on the remote server **62**. Additionally, relevant information regarding the vehicle (e.g., vehicle location, vehicle model, engine size, etc.) or a service station (e.g., service station location, inventory, available special price offers, etc.) may be stored in the remote server **62** to be sent by the cloud network **98**, **112**, or **122** to the user. Additionally, the cloud network **98**, **112**, or **122** may track the purchase of a previous battery and/or store a determined estimated end of life for the battery and sends appropriate information to the user based on the estimated end of life, position of the vehicle, available special price offers, service station inventory, and/or other suitable information.

The invention claimed is:

1. A battery, comprising:

a battery monitoring system integrated within the battery, wherein the battery monitoring system comprises:

a diagnostic system configured to monitor or store at least one parameter of the battery;

a receiver communicatively coupled to the diagnostic system; and

a transmitter communicatively coupled to the diagnostic system, and configured to activate upon receipt of a first wireless signal by the receiver and to transmit a second wireless signal indicative of the at least one parameter of the battery;

wherein the at least one parameter of the battery comprises a time, a voltage, a temperature, or a current; and

wherein the time corresponds to a time after manufacture of the battery, and the diagnostic system is configured to activate the diagnostic system after the time passes a threshold value.

2. The battery of claim **1**, wherein the receiver is configured to receive the first wireless signal from a transmitter remote from a system that encloses the battery.

3. The battery of claim **1**, wherein the first signal comprises an optical light signal.

4. The battery of claim **1**, wherein the first signal comprises a radio frequency signal.

5. The battery of claim **1**, wherein the transmitter is configured to transmit the second wireless signal to a receiver remote from a system that encloses the battery.

6. The battery of claim **1**, wherein the second wireless signal comprises a radio frequency signal.

7. The battery of claim **1**, wherein the second wireless signal comprises a visual signal or an audio signal.

8. The battery of claim **1**, wherein the battery monitoring system comprises a transceiver having the receiver and the transmitter.

9. The battery of claim **1**, wherein the receiver is configured to receive a third wireless signal, wherein the battery monitoring system is configured to activate a standby mode when the receiver receives the third wireless signal.

10. The battery of claim **9**, wherein the battery monitoring system is configured to deactivate the standby mode upon detection of a voltage change in the battery, current draw on the battery above a current threshold, an lapse of time greater than a time threshold, a fourth wireless signal received by the receiver, or some combination thereof.

11. A method for monitoring a battery, comprising:

wirelessly receiving a first signal via a diagnostic system integrated within the battery, wherein the first signal is indicative of activation of a transmitter of the diagnostic system;

monitoring at least one parameter of the battery via the diagnostic system;

monitoring a time after manufacture of the battery and activating the transmitter of the diagnostic system upon a duration of time after the manufacture of the battery; and

wirelessly transmitting a second signal indicative of the at least one parameter of the battery upon receipt of the first signal.

12. The method of claim 9, wherein the at least one parameter of the battery comprises a battery voltage, a battery temperature, and a battery current.

13. The method of claim 9, wherein the second signal comprises a radio frequency signal.

14. The method of claim 9, wherein the at least one parameter of the battery comprises an end of life of the battery.

15. The method of claim 9, wherein the first or second signal comprises an optical light signal.

16. The method of claim 9, wherein the first signal is transmitted by a device remote from the battery.

17. A battery system, comprising:

a battery;

a communication device remote from the battery and configured to receive a wireless signal

a battery monitoring system integrated within the battery, comprising:

a diagnostic system configured to monitor at least one parameter of the battery, wherein the diagnostic system is configured to activate upon a duration of time after manufacture; and

a transmitter communicatively coupled to the diagnostic system, and configured to transmit the wireless signal indicative of the at least one parameter of the battery.

18. The battery system of claim 17, wherein the wireless signal is also indicative of the at least one parameter, and the at least one parameter comprises at least one of battery voltage, battery current, and battery temperature.

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